

# A NEW NEMATODE FROM THE RAT, AND ITS LIFE HISTORY

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Through the courtesy of the superintendent of the National Zoological Park, Washington, D. C., there were turned over to the present writer about 20 wild rats (*Rattus norvegicus*) which had been killed in the Park. Upon postmortem examination the large majority of the rats were found to harbor spirurid worms. The nematodes were unusually large, and present in such numbers that in many cases the stomach, esophagus, and upper end of intestine were distended and densely packed with the worms. Upon examination the nematode proved to be a new species of *Protospirura*. Several rats caught in another part of Washington (Department of Agriculture buildings, about 5 miles from the Zoological Park) failed to show the presence of these nematodes and the high percentage of incidence in wild rats from the grounds of the Park therefore suggested that the rat was not the normal or original host but had derived the infestation from some other rodent present in the Zoological Park. The possibility that zoological gardens might act as disseminators of parasites and that the rat might play an important role in that dissemination is worthy of consideration, and it was thought by the present writer that a study of this nematode and its life history might have practical as well as scientific interest. The description of the parasite and the experiments on its life history are given below.

## PROTOSPIRURA COLUMBIANA, new species

*Specific diagnosis.*—*Protospirura*: Large worms, the variations of size of the adult worms, however, being unusually extensive. Cuticle with transverse striations and, in addition, thrown into loose folds, the cuticle being so loose and distended in many of the worms as to give the appearance of a larval cuticle about to be shed. Head with 2 large trilobed lips. The lobes are of approximately equal size, but the lateral lobes taper somewhat anteriorly, whereas the 2

median lobes are broadly rounded. Each lobe has on its inner surface an anteriorly projecting plate, the free edge of which is dentate, that of the median lobe having a large central tooth and at each side 4 or 5 smaller teeth; that of the lateral lobes 3 teeth at each side of the large central one. The lobes of each lip appear quite discreet, there being considerable space between them; they have a heavy chitinous lining. Four submedian papillae present. Mouth opening oval, elongate dorso-ventrally; pharynx large, cylindrical, its diameter increasing somewhat posteriorly. Nerve ring surrounding esophagus near its anterior end; cervical papillae very small, located in depressions of the cuticle at the level of the nerve ring; excretory pore a short distance posterior to the nerve ring.

*Male*.—Total length 22 to 43 mm.; width  $600\mu$  to 1.2 mm. In a specimen of medium size the width of the head at base of lips is  $160$  to  $165\mu$ ; the lips are  $50\mu$  long, the median lobe  $58\mu$  wide; width of body at posterior end of esophagus  $500\mu$ , at the curve of the caudal end  $500\mu$ , at the level of the cloacal aperture  $350\mu$ . Pharynx  $150$  to  $160\mu$  long by  $60$  to  $75\mu$  wide; esophagus 4.2 mm. long ( $\frac{1}{4}$  of total body length) by  $300\mu$  in maximum width; nerve ring  $200\mu$  from anterior end of esophagus. Posterior end of body tightly coiled. Tail short, the cloacal aperture  $\frac{1}{5}$  of total body length from posterior end. Two caudal alae of approximately equal size, measuring 1.4 mm. long in large specimens; the maximum width of  $265\mu$  attained at about the middle of their length; they have fine wavy transverse striations and their outer edge is irregular. Ventral surface of body for a distance of 5.5 to 6 mm. anterior to caudal end provided with vesicular swelling of cuticle. As seen from the ventral surface, with the cover glass compressing the vesicular inflation of the cuticle laterally, the caudal alae are completely hidden from view, lying dorsal to this inflation. The latter is covered with rounded oblong markings of varying size, similar to those found in other species of the genus. In addition to the oblong markings, and correlated with them, are brilliantly refringent dots, confined to the ventral region and the posterior half of the vesicular inflation, gradually disappearing laterally and anteriorly. These dots are not superficial, as are the markings, but lie just below the surface. Not only the circumcloacal region but also the median ventral surface of the body from the cloacal aperture to the tail end is devoid of both the oblong markings and the dots. Six pairs of long pedunculated papillae, of which four pairs are preanal and two pairs postanal; in addition there are five pairs of very small sessile papillae at the caudal extremity, which are not apparent except in a direct ventral view of the tail. Spicules slightly unequal, the one 1.3 to 1.4 mm. long by  $33$  to  $37\mu$  wide, with distal end rounded; the other 1.03 to 1.07 mm. long by  $18\mu$  wide, with distal end sharply

pointed. The sheath of the longer spicule is strongly developed; when the spicule is extruded the sheath is compressed accordion-like, its numerous ridges or folds being seen clearly through the body wall when the specimen is cleared, whereas when the spicule is completely drawn into the body the sheath is extended so that its walls are smooth. There is a distinct telamon present, sharply limiting the cloacal aperture; it appears to be horseshoe shaped, the open ends directed anteriorly.

*Female*.—Total length 45 to 100 mm.; width  $800\mu$  to 2.4 mm. In a specimen of medium size the width of head at base of lips is  $265\mu$ , the pharynx  $215\mu$  long, its lumen  $66\mu$  in diameter, its walls  $17\mu$  thick. Esophagus 6.4 mm. long ( $\frac{1}{12}$  of total body length), the nerve ring  $250\mu$  from its anterior end. Uterus extends anteriorly to a point 1.7 mm. posterior to the junction of esophagus and intestine. Caudal extremity bluntly rounded, the cuticle thrown in loose folds. The anus is not situated at the level of the superficial cuticle but at the bottom of a channel formed by a prepuce-like sheath. The anus is  $750\mu$  to 1.2 mm. from tail end whereas the opening of the sheath is 400 to  $580\mu$  from the extremity. Vulva inconspicuous, situated slightly anterior to middle of body, dividing the body length in ratio of 4:5. The posteriorly-directed vagina,  $531\mu$  long, is followed by a slightly enlarged sphincter,  $183\mu$  long, and that by the unpaired portion of the uterus which after a length of 1.6 mm. divides into the two divergent uterine branches. Eggs 52 to  $58\mu$  by 30 to  $33\mu$ ; the embryo, measured after being released from the shell,  $232\mu$  long by  $10\mu$  wide, with a small knob bearing minute spines at its tail end.

A male and female were observed in copula (fig. 9), the posterior end of the male being tightly coiled around the body of the female, in the region of the vulva. The tight clasp constricts the female body very decidedly anterior to the vulva and suggests that its purpose may be not only to secure the female but possibly to dilate the vulva and vagina.

*Fourth-stage larva* (fig. 13) 6.6 mm. long by  $257\mu$  wide to 11.5 mm. long by  $300\mu$  wide; first part of esophagus  $150\mu$ , second part of esophagus 3.3 mm. long; anus  $216\mu$  from tail end.

*Host*.—*Rattus norvegicus*.

*Location*.—Stomach and, occasionally, esophagus and anterior end of small intestine.

*Locality*.—Washington, D. C.

*Type material*.—No. 26383, paratypes No. 26384, U.S.N.M. (Bureau of Animal Industry) Helminthological Collections.

*Life history*.—On October 2, 1924, a culture was made in physiologic saline solution of embryonated eggs from the uteri of several worms and fed on bread to several cockroaches (croton bugs or

*Ectobia germanica*). On October 6 the culture was found to be covered with a heavy mold but the eggs were apparently unharmed as no change was apparent in them. The culture was divided into 3 parts and to these were added the following, respectively: charcoal, a little potassium bichromate and about 2 per cent formalin. The roaches were fed from these cultures at irregular intervals during the month of October.

On October 26 one roach was found dead. Upon dissection numerous larvae of various sizes were found free in the body cavity; none could be found to have encysted. The larvae (apparently second stage) measured  $90\mu$  to 1.1 mm. long; the tail end was devoid of spinous processes.

On November 3 the dissection of a second roach, found dead on that day, revealed a large number of spirurid larvae, in the loose tissue of the body cavity, especially in that around the tracheal tubes. Many of the larvae were coiled in a tight spiral and exhibited very sluggish movement; several were in loose cysts. The larvae (apparently third stage) measured 1.1 to 1.2 mm. long by  $50\mu$  wide; first part of esophagus  $66\mu$  long, second part of esophagus  $440\mu$  long, anus  $75\mu$  from tail end. In lateral view the end of the tail showed 4 spinous processes, the 2 median being larger than the 2 outer. About 10 larvae were fed to a white mouse and about 20 to a white rat. The mouse died on November 17 but no spirurids were found in the stomach or esophagus; the rat was killed on December 27 and the findings in regard to it were also negative.

On November 13 a roach which was killed and dissected, was found to have 19 encysted larvae in the abdominal cavity. Six of the larvae were fed to a white mouse which died on November 15 with evidences of hemorrhage, there being blood at the mouth and blood clots in the stomach. One spirurid larva was found in the stomach; it was of about the same size (1.2 mm. by  $50\mu$ ) as the encysted ones which had been fed.

On December 1 a roach which was killed and dissected was found to contain numerous encysted larvae in the abdominal and thoracic cavities, the cysts being loose among the tissues around the mouth parts, in the fleshy coxa of the legs, and among the salivary glands and the Malpighian tubes. Forty-three cysts were collected, a few of them containing 2 larvae but the great majority only one. The cysts measured about 425 to  $440\mu$  in diameter; the larvae were the same size (1.2 mm. by  $50\mu$ ) as those collected from roaches previously examined. A white mouse was fed 8 cysts, and 2 white rats 12 cysts apiece. The mouse died on December 15 but no spirurids could be found in the esophagus or stomach. One of the rats was killed on January 5 and 4 immature specimens of *P. columbiana* found in the stomach, 3 males (17 to 20 mm. long by 450 to  $500\mu$  wide) and 1

female (28 mm. long by 500 $\mu$  wide). The second white rat died on January 23; upon postmortem examination 2 specimens of *P. columbiana*, mature but not fully grown adults, were found in the stomach, one male (24 mm. long by 500 $\mu$  wide) and one female (30 mm. long by 850 $\mu$  wide).

On December 27 encysted larvae, obtained by dissection of one of the remaining roaches, were fed to white rates and mice. On April 21, 2 of the rats and 1 mouse were killed. From the stomach of one rat were recovered 8 specimens of *P. columbiana* (7 females and 1 male), from that of the second rat 7 specimens (3 females and 4 males), and from that of the mouse 1 specimen (male). These nematodes had attained the size of those found originally in the wild rats, the females measuring up to 88 mm. long by 2.2 mm. wide, the males up to 43 mm. long by 1 mm. wide.

A tabulated summary of the above feeding experiments is as follows:

Roaches		Rats and mice	
Time between feeding and death	Findings	Time between feeding and death	Findings
<i>Days</i>		<i>Days</i>	
23-----	Numerous larvae (1.0 to 1.2 mm. long) free in body cavity.	13-----	negative.
		54-----	negative.
31-----	Many larvae (1.1 to 1.2 mm. long by 50 $\mu$ wide; mostly free, a few in cysts).	2-----	1 spiruid larva in stomach.
		14-----	negative.
41-----	19 encysted larvae (1.1 mm. long).	35-----	4 spirurids in stomach, ( <i>P. columbiana</i> , 3 $\sigma$ (17 to 20 mm. long), 1 $\varphi$ (28 mm. long)).
58-----	Numerous encysted larvae (1.1 to 1.2 mm. long).	53-----	2 spirurids in stomach 1 $\sigma$ (24 mm. long), 1 $\varphi$ (30 mm. long)).
85-----	Numerous encysted larvae.	115-----	1 spirurid in stomach ( $\sigma$ , 38 mm.).
197-----	Numerous encysted larvae.	115-----	8 spirurids in stomach (1 $\sigma$ (43 mm. long), 7 $\varphi$ (up to 85 mm. long)).
		115-----	7 spirurids in stomach (4 $\sigma$ (up to 43 mm.), 3 $\varphi$ (up to 88 mm. long)).

#### KNOWN SPECIES OF PROTOSPIRURA

The species of the genus *Protospirura* may be distinguished as follows:

- Each lobe of lips with 1 large tooth and 2 smaller teeth; 6 cephalic papillae: eggs 16 $\mu$  long by 7 $\mu$  wide----- *P. labiodentata*. Lobes of lips with teeth of different number than above; 4 cephalic papillae: eggs, where known, much larger than 16 $\mu$  by 7 $\mu$ ----- 2.



2. Only male known, 23 mm. long by  $564\mu$  wide; spicules  $622\mu$  and 1.1 mm. long----- *P. gracilis*.  
Both male and female known, the male not as slender as  $564\mu$ ; spicule lengths different from those of *P. gracilis*----- 3.
3. Median lobe of lips toothless; vulva at level of posterior third of body, dividing body length in ratio of 2:1; spicules equal,  $395\mu$  long-- *P. bonnet*  
Median lobe of lips with teeth; vulva anterior to middle of body; spicules unequal, the long spicule always more than  $395\mu$ ----- 4.
4. Long spicule not over  $830\mu$ ; short spicule not over  $420\mu$ ----- 5.  
Long spicule over 1 mm.; short spicule  $622\mu$  or longer----- 6.
5. Long spicule  $830\mu$ ; short spicule  $420\mu$ ----- *P. numidica*.  
Long spicule  $480\mu$ ; short spicule  $350\mu$ ----- *P. muricola*.
6. Vulva a little anterior of union of anterior and middle third of body; difference in length of the 2 spicules more than  $500\mu$ ----- *P. ascaroidea*.  
Vulva slightly anterior of middle of body; difference in length of the 2 spicules not over  $300\mu$ ----- 7.
7. Male not over 28 mm. long; female not over 40 mm. long; median lobe of lips with a large central tooth and 2 smaller teeth on each side; tail of male  $1/41$  of total body length----- *P. muris*.  
Male up to 43 mm. long; female up to 100 mm. long; median lobe of lips with a long central tooth and 4 or 5 smaller teeth on each side; tail of male  $1/50$  of total body length----- *P. columbiana*.

## SUMMARY.

A new species of nematode, *Protospirura columbiana*, was found in the stomach and esophagus of wild rats (*Rattus norvegicus*) killed at the National Zoological Park, Washington, D. C. Life history experiments resulted in the successful development of the encysted larval stage of the nematode in cockroaches (croton bugs, *Ectobia germanica*). The larvae begin to encyst about one month after the eggs are fed to the roaches, but they are apparently not infective at that time. After 41 days they appear to have reached the infective stage, one of the larvae being present in the stomach of a mouse at its death 2 days after the feeding of the encysted form. Adult nematodes were developed in rats by feeding the encysted larvae obtained from a roach 58 days after the latter was fed the embryonated eggs. The nematodes are still immature 35 days after the feeding of the final host; after 53 days they are mature but not fully grown, whereas after 115 days they have attained the size of the majority of the nematodes found in natural infections.

The only other life history of a species of *Protospirura* that appears to be known is that of *P. muris*. Leuckart (1867) and Marchi (1871) found that encapsuled larvae develop in meal worms, *Tenebrio* species, about 5 weeks after the nematode eggs had been eaten by the worm.

The finding of *P. columbiana* in wild rats in the Zoological Park but not in those from other parts of the city suggests the possibility

that the normal host may be a rodent other than the rat, present in the Park. That rats and cockroaches, pests commonly present around such places, may play a part in the dissemination of parasites formerly absent in a country but brought in by the animals in the Zoological Park, is a possibility the recognition of which might have a practical significance.

## EXPLANATION OF PLATES

## PLATE 1.

*Protospirura columbiana, new species*

- FIG. 1. Head, lateral view.  
2. Head, en face view (same magnification as fig. 1).  
3. Tail of male, lateral view.  
4. Tail of male, ventral view.  
5. Caudal end of male.  
6. Tail of female.

## PLATE 2.

*Protospirura columbiana, new species*

- FIG. 7. Terminal genitalia of female.  
8. Vulva and anterior end of vagina.  
9. Male and female in copula.  
10. Egg.  
11. Tail of third stage larva, before encystment.  
12. Tail of third stage larva, after encystment.  
13. Tail of fourth stage larva.

